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DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

RECENT CHANGES in the CALIFORNIA DESIGN METHOD for STRUCTURAL SECTIONS OF FLEXIBLE PAVEMENT

By
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The California design formula for structural design of pavement sections was first presented in 1948 and the modifications recently adopted are the first changes in a ten year period. It is hoped that this discussion of these changes will lead to a better understanding and use of the formula.

All structural design methods in use today are empirical or at least contain some factors which are of empirical origin. This poses some uncertainty for empirical formulae are often derived from experimental data obtained for a specific set of conditions. In a complex roadway structure the conditions on a limited number of jobs may include only a limited number of variables. Herein lies the basic reason for the changes in the California formula for as experience has accumulated we have found that present day volumes of traffic are exceeding the range of values for which our original formula was devised.

The 1950's have seen a marked increase in the tempo of highway construction. Contractors are using bigger and more powerful equipment and it has become more and more difficult for the engineer to exercise the proper control of quality. During this period, also, traffic has shown a great increase not only in total numbers,

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but in average axle loads. Keeping pace with increased traffic, maintenance of the traveled way has become more complicated. As traffic increases the repair work on highways constitutes a greater interference with traffic. In an extreme case, for example, the heavy traffic on some freeways in the Metropolitan Los Angeles area requires that maintenance work be performed at night in order to avoid traffic congestion. All these factors add up to the need for modification and the introduction of larger factors of safety in the design formula if we are to build highways with adequate structural life.

The California Division of Highways has been working on the problem of structural design for a good number of years. Several major papers have been presented on this subject; two by Fred J. Grumm (1) and (2) of the Design Department, were published in 1942 and developed a method of design based upon the CBR method of test. Also published in 1942 was the paper, "Foundations for Flexible Pavements" by O. J. Porter (3). In 1948, F. N. Hveem and R. M. Carmany published a paper entitled, "The Factors Underlying the Rational Design of Pavements" (4). This latter paper developed the formula we have used for the past eight years and employs the stabilometer as its basic test.

The work we have done has led us to be reasonably certain that any pavement design formula to be comprehensive must include at least three factors. It must have a factor to represent the destructive effect of traffic, a factor to evaluate the resistance to displacement of the soil under the protective layers of pavement and base and a factor to evaluate the cohesion or tensile strength of various layers in the structural section. It was based upon this concept that the 1948 general formula was developed for determining the thickness of various elements of the structural section. The general formula is as follows:

$$T = 0.095 \frac{(\text{Traffic Index})(90-R)}{\sqrt[5]{\text{cohesion value}}}$$

Where T = required thickness of cover
R = resistance value by stabilometer

The changes recently adopted have not altered the basic terms of the above formula. The constant 0.095 is retained and the resistance value, "R", is still determined by stabilometer test. The traffic index and estimate of pavement slab strength (cohesion) however, are calculated by revised methods which result in a net effect of thicker pavements for heavy traffic highways and thinner pavements for lightly traveled roads and streets.

In changing the factors in the formula it was found necessary to depend to a large extent on test road and laboratory data. It would have been desirable to use data from existing roadways. However, there are serious obstacles to this form of approach. In the first place, any road that does not fail is difficult to analyze because its total life is unknown. Secondly, at the time of a road failure it is usually impossible to accurately determine the weight and amount of traffic that has used the road during its service life or to determine the cycles of subsurface moisture conditions to which the pavement has been subjected. Another factor is that engineers rarely agree on the degree or extent of distress which will class a road as a failure. Maintenance men are excepted, of course. In many cases an accurate survey of a road classed as failure may indicate not over 1% area of failure. Finally, the evaluation of existing road conditions produces data of such extent and scope that it is relatively impossible to relate all the variables and conditions. Perhaps the future use of computing systems will solve this problem.

In the design formula the effect of traffic is expressed in terms of a "traffic index" and as can be seen the thickness required will be directly proportional to the traffic index. The importance of this factor has been many times demonstrated by the performance of multilane roads where distress occurs generally in the outer or traveled lanes and rarely in the inner or passing lanes.

The destructive effect of traffic, includes two principal variables, repetitions and load both of which should be evaluated. Further, it is most convenient if their effect can be estimated from a simple count of vehicles. Such a system has been used in both the old and revised California formulas for evaluating the destructive effect of traffic.

As originally used, our traffic index was calculated from constants derived in the Grumm article of 1942. In this article the concept of expressing all traffic in terms of the equivalent 5,000 lb. wheel load (EWL) was presented and the effect of loads greater than 5,000 lb. was evaluated by means of numbers in a geometric progression. In this geometric progression, which is shown on page 5, the actual wheel loads in lbs. were arbitrarily related to wheel load constants

Wheel Load Pounds	EWL Constants
5000	1
6000	2
7000	4
8000	8
9000	16
10000	32

Note that one passage of a 9 kip wheel load is rated as equivalent to 16 passages of a 5,000 lb. wheel load.

In 1947, A. M. Nash published in a circular letter (5) the concept of using yearly constants as multipliers to obtain an estimate of the yearly EWL for various truck classes such as 2, 3, 4, 5 and 6 axle trucks. After obtaining the total yearly EWL for all such classes of trucks, this figure was projected into the future to give an estimate of the EWL expected to use the road during its first 10 years of life. When the 1948 formula of Hveem and Carmany was adopted the following empirical formula was used to calculate the traffic index.

$$\text{Traffic Index} = \frac{4 \log \text{EWL} - 2}{3}$$

The principal weakness in this formula appeared to be that it concentrated traffic effect in a too narrow band, classifying all traffic in the state between the limits of 6 and 10 traffic indices. This did not agree with engineers experience as we received complaints on one hand, from county engineers claiming that the lower range of the traffic index required too thick a structural section for light traffic and on the other end of the scale complaints were received that the sections were too thin for heavy traffic. The middle ranges of the formula appeared satisfactory since very little comment was received about them. The complaints concerning heavy traffic are confirmed by the fact that most of the distress is occurring on our roads which carry a large number of heavy vehicles.

It seemed to us in the laboratory that if we were to accurately evaluate the effect of traffic we must derive our information from the controlled conditions of test roads, since trends developed by them should be more reliable than those developed from visual examinations of ordinary roadways. Further, these trends should be developed from test roads which used a wide enough range of loads over similar soils to give some idea of the shape of our design curves beyond ordinary highway loading. We found only two test roads which suited our purpose. First, our own Brighton Test Road which was operated in 1940 to 1942 and secondly, the Corps of Engineers' Stockton Test Road operated in 1942. Both of these test roads had approximately the same basement soil conditions, both were constructed with 2" plant mixed surfacing, and were constructed on the wedge shape principle. The thickness of section required for various numbers of load repetitions on these two test roads are shown as a logarithm plot in Figure I. Included are the 6,000 lb. wheel load of the Brighton Test Road and the 25,000 lb. and 40,000 lb. wheel loads used on the first Stockton Test Road. It can be seen that plots for both the 40,000 lb. and the 6,000 lb. wheel loads are straight lines with approximately the same slope. The different slope of the 25,000 lb. wheel load is greatly influenced by the thickness required at 53 repetitions, and since we have additional supporting data from the Brighton test which parallel the 6,000 lb. curve we decided to neglect the effect of the 25,000 lb. wheel load in determining the average slope of the curves. The average slope, therefore, became 0.113 making the relationship between repetitions and thickness

$$T = K_1 \ (r)^{0.113} \tag{1}$$

Where T = thickness of structure
r = repetitions of load
K_1 = a constant

Figure II shows the effect of pavement thickness vs. wheel loads for the various groups of repetitions. Our best estimate of the average slope of this group of curves is 0.57, giving the following relationship for the effect of load.

$$T = K_2 \ (W)^{0.57} \tag{2}$$

Where W = wheel load

combining the effect of wheel loads and repetitions we can reasonably well express the combined effect of repetitions and load by

$$T = K_3 \ (W)^{0.57} \ (r)^{0.113} \tag{3}$$

By use of equation (3) in the following proportion equivalent 5,000 lb. wheel load constants somewhat similar to the 1, 2, 4, 8 series previously used under the Grumm method may be derived

$$\frac{T_1}{T_2} = \left(\frac{W_1}{W_2}\right)^{0.57} \left(\frac{r_1}{r_2}\right)^{0.113}$$

making $T_1 = T_2$, W_1 = 5,000 lb. and r_2 = one repetition of load W_2 the equivalent wheel load constants for any wheel load W may be calculated from the formula

$$r_1 = c = \left(\frac{W_2}{5}\right)^5 = \left(\frac{W}{5}\right)^5 \qquad (4)$$

Where W = load in kip
c = a constant for any given wheel load and is the equivalent 5,000 lb. wheel loads for one application of load W

A plot of these constants for various loads is shown in Fig. III.

Also plotted on Fig. II are the final thickness-load relationships for the four loads used on the WASHO Test Road and from these data it can be seen that for equal wheel load, tandem axles are somewhat more destructive than single axles. A pair of wheel loads in close proximity apparently cause as much damage as a single load 20 per cent heavier than the tandem individual wheel loads. In terms of potential damage, one passage of a 32 kip tandem truck appears to be equivalent to one passage of a 19.2 kip single axle truck and one passage of a 40 kip tandem is equivalent to one passage of a 24 kip single. The tandem effect is also plotted on Fig. III. This relationship will vary somewhat depending upon the type of pavement with the more rigid pavement accentuating the tandem effect and the more flexible pavements such as a thin armor coat surfacing allowing the axle loads to act independently.

From the constant, c, derived in formula (4) we can calculate for each of the test loads shown in Fig. I their equivalent number of 5,000 lb. wheel loads simply by multiplying the wheel load constant by the number of repetitions of that particular wheel load indicated for the various thicknesses. Since the plot of thickness versus EWL, Fig. IV, is a straight line we are furnished proof that our analysis is correct. The equation for this correlation curve is

$$T = K_4 \, (EWL_{57})^{0.11} \tag{5}$$

Where K_4 is a constant

Also plotted on Fig. IV are the data for the WASHO Test Road. When corrected for tandem effect these data approximate a straight line parallel to that obtained for the California test tracks. The difference in ordinates is believed to be due to a difference in basement soils with the California tracks being built on somewhat poorer soils that were kept saturated by water introduced through perforated pipes in the subbase layers.

Since thickness is directly proportional to traffic index the equation for traffic index is of the same form as equation (5) or

$$\text{Traffic Index} = 1.35 \, (EWL_{57})^{0.11} \tag{6}$$

In formula (6) above, the constant K_4 was chosen as 1.35, because this value gives the best correlation with the WASHO Test Road. It provides 19" of cover for 238,000 applications of a single axle, 18,000 lb. axle load. This is 3" greater than the reported test findings (6) indicated to be necessary. However, we feel that a design formula should not give thickness values that are barely adequate without any factor of safety. Actually this factor of safety is needed to allow for variable conditions. This, also, was demonstrated by the WASHO Test; where even though the engineering analysis showed that theoretically 16" of cover should have been satisfactory for 238,000 repetitions of the

18,000 lb. single axle load it is a matter of record that this loading caused considerable damage in a section with 18" of cover. Therefore, a constant which gives 19" of cover only furnishes a minimum factor of safety and is not excessive for normal variations in road construction.

For design purposes, it is obviously impossible to weigh all trucks on each and every highway in order to arrive at a design criterion. Therefore, in California we have resorted to the statistical substitute of obtaining a measured sample of the traffic and by proper location of loadometer stations on principal highways we obtain a fairly satisfactory picture of the distribution of different types of trucks and their average wheel loads. The development of this method is shown in the attached Table I, where axle weights at various loadometer stations have been grouped together to give a statistical picture of load variations within each particular class of trucks, such as 2, 3, 4, 5 or 6 axle trucks. It will be noted in the table that the wheel load factors for the 3, 4, 5 and 6 axle trucks show some variation within a given wheel load group. This is due to the allowance for the tandem effect.

Table II shows the totals arrived at in Table I and develops the EWL_{57} constants for converting average daily traffic to yearly equivalent wheel loads. The subscript "57" is used to differentiate from EWL's calculated by methods established in previous years. Since in California our traffic counts are reported as the total vehicles in two directions the constants developed in Table II are for use with these bidirectional counts. It should be pointed out at this point that the Table II constants are based on 1956 traffic and that increasing average wheel load trends will cause these constants to increase in future years.

The Division's Planning Survey Department makes extensive traffic surveys and counts various classes of trucks at a number of locations for two days a year (a Sunday and Monday in mid July). At a lesser number of stations one day monthly counts are made. A third set of counts is made at stations operated annually for seven consecutive days including the period of the two day counts. From these three traffic counts the average daily truck traffic for each class of trucks is determined for every county, route and section in the State Highway System. Multiplying these numbers of trucks by their appropriate constants, as shown in the example below, we obtain the total yearly EWL for a particular section of highway.

Road VI-Fre-4-A

Truck Class By Axles	*No. of Trucks	EWL-Yearly Constants	Yearly EWL
2	679	330	224,070
3	344	1070	368,080
4	295	2460	725,700
5	1539	4620	7,110,180
6	113	3040	343,520
		Total yearly EWL	8,771,550

*2 directional count

Having obtained the yearly EWL our traffic engineers project this figure and determine the total number of equivalent wheel loads which are expected to use the highway during a ten year life. Substituting this 10 year figure in equation (6), the traffic index is calculated for use in the design formula.

Typical ranges of traffic index are shown in the table below

Class of Road	Traffic Index Range
Heavy Industrial	10-12
Heavy Truck Traffic	9-10
Average Highways	7-9
Shoulders and Frontage Roads	4.5-7.5
Residential Streets	2-5

In applying this method of determining traffic effect a word of caution is necessary. For their most accurate use the EWL constants developed in this paper should be applied principally to roads where the trucks carry loads approximating the weight pattern measured by our loadometer stations. This pattern primarily represents major highways carrying the greatest number of trucks. It is obvious that roads having a high percentage of fully loaded trucks (logging roads are a prime example in our state) or roads carrying a high percentage of light or unloaded trucks (farm to market roads sometimes fall into this category) will not conform to the EWL constants derived in Table II. For these special conditions loadometer studies need to be made and more suitable EWL constants developed.

Another major factor of the design formula is evaluation of the ability of a soil to resist deformation under load. This is accomplished by determining a resistance value "R" of soil using the stabilometer test method. This method consists basically of applying a vertical load to a 2-1/2" high x 4" diameter test specimen. The portion of the load transmitted laterally to the sides of the specimen is measured by the stabilometer. Materials are rated on a scale of 0 to 100 in proportion to their ability to sustain load without transmitting pressure to the side walls. A liquid, therefore, would have zero resistance value; whereas, steel would have 100 under the loads applied.

In the design formula the term (90-R) relates resistance value to thickness of structure. Work in the laboratory did not indicate the need of any major change in this factor and since minor changes would require revision of all existing design charts and slide rules this factor was left unchanged.

The WASHO Road Test clearly indicated a marked superiority of 4" over a 2" layer of hot mixed surfacing. It also demonstrated that paved shoulders provide support to the traveled way. In each case it was indicated that strength in the upper layers could result in savings in total pavement thickness. In the design formula this effect is accounted for by the cohesion factor.

The cohesion value of the design formula is a measure of the tensile strength which in turn determines the slab strength of the structural layers. It is determined by bending a 2-1/2" high by 4" diameter test specimen along a diameter until rupture occurs. The test is made in an instrument known as the Cohesiometer and since the breaking mechanism is hinged on the lower face of the specimen, the specimen is broken, theoretically, in pure tension.

Load is applied to the specimen by a stream of shot or water flowing at a controlled rate into a loading bucket. The Cohesiometer value is expressed as load in grams per lineal inch of specimen required to break the specimen.

In the former design formula thickness was found to be inversely proportional to the 5th root of the cohesion value. Additional studies did not indicate that any change was necessary in this relationship. However, it was indicated that we were somewhat optimistic in the cohesion values originally assigned to both plant mixed surfacing and cement treated bases. This was brought out by a long series of tests made in our laboratory. From these test results we deduced that our cohesion values of 3000 for Class A cement treated base and 1500 for Class B base should be reduced to design values of 1500 and 750, respectively. Class A cement treated base is one designed for 650 lb. per square inch compressive strength at 7 days while Class B base is designed for 300 lbs. per square inch at 7 days.

Our value of 600 cohesion for plant mixed surfacing was arrived at several years ago when our old asphaltic concrete design was in vogue. The more open graded plant mixes now in use require that a lesser cohesion be used. A design value of 400 is believed more representative of present day construction.

In using the cohesion value in the design formula it is necessary to modify the basic Cohesiometer values if the soil under test is covered by a multilayer system. A basement soil, for example, might be covered with a 4" layer of plant mix, an 8" layer of Class B cement treated base, and a 6" layer of subbase material. Each layer is assigned a different effective cohesive strength, making necessary a formula or method of combining the three cohesion values to obtain one value for use in the design formula.

The discarded formula for combining cohesions was based on a flexural theory which laboratory tests failed to verify, especially for combinations of plant mixed surfacing and cement treated base. The revised formula has greatly simplified the calculation of combined cohesion by substituting a method of equivalent thicknesses in which thicknesses of treated or cemented layers are expressed in terms of gravel thickness. The following table shows the design cohesion values and equivalent thicknesses per inch of the indicated materials.

Type of Material	Cohesion Value	Equivalent Inches of Gravel
Class A Cement Treated Base	1500	1.72
Class B Cement Treated Base	750	1.50
Plant Mixed Surfacing (Paving Grade Asphalt)	400	1.32
Road Mixed Surfacing (Liquid Asphalt)	150	1.08
Untreated Base	100	1.00

In the stabilometer method of test we determine that a certain thickness of gravel will protect a soil from distortion under a given traffic load. As illustrated in the WASHO Test, however, when the top layers of the roadway consist of plant mix or other treated materials having measurable slab strength certain reductions in thickness may be achieved. For example, if it is found that a native basement soil requires 23" of gravel cover for a satisfactory structural section and the planned cover includes 4" plant mixed surfacing and 8" cement treated base, the total structural thickness may be reduced as follows:

$$\begin{aligned} 4 \times 1.32 &= 5.28 \\ 8 \times 1.50 &= \underline{12.00} \\ & \quad 17.28\text{" use } 17\text{"} \end{aligned}$$

The use of 12" of the higher strength treated layers in the upper portion of the structure is equivalent to 17" gravel cover. This results in a 5" saving in total thickness in the above example and requires only a 6" layer of subbase along with the treated layers to satisfy the design.

For several years it has been the Materials and Research Department's responsibility to investigate projects showing signs of distress. As a result we feel that there are certain practical aspects in the use of a design formula which can not be overlooked. Investigations have revealed that the structural elements of a road are, at times, not constructed to the design thickness. Quite often this deviation from the plans results from the tolerances allowed in making subgrade. A basement soil, for instance, may be finished to a grade of ± 0.1 feet. The top of the subbase layer is subject to the same tolerances. The thickness of the 6" layer can, therefore, legally show a variation of 4" to 8". Test holes have confirmed that this occasionally occurs. In most cases the proper average of 6" thickness will be achieved. Unfortunately, a road first fails under its weakest condition and in its weakest spots and not necessarily where average conditions prevail.

In addition to variations in structural thicknesses there are certain limitations, for construction reasons, in the thickness of layers. For example, it has been found through experience that base layers should not be placed less than 4" thick. Neither can they be placed in layers greater than 7" without sacrificing compacted density. Since any design formula is based upon achieving certain compaction during construction, it is necessary that construction forces insist upon proper thickness of lifts and proper compaction of structural materials.

With the increased pace of construction it is essential that the design formula should contain a factor of safety but in addition it is also desirable that this factor of safety be on a sliding scale related to the intensity of traffic. That is, heavily traveled freeways should be built with higher standards than lightly traveled rural roads. Our Design Department has accomplished this by requiring thicker surfaces and bases than the theoretical minimum indicated as necessary by the design formula on roads of high traffic index.

In the foregoing paper an attempt has been made to present the changes that have been made in the California design formula and the reasons for making them. While the general design formula

$$T = 0.095 \frac{(\text{Traffic Index})(90-R)}{\sqrt[5]{\text{Cohesion value}}}$$

has remained the same, the methods of evaluating the factors of traffic index and assumed Cohesiometer values have been revised. It is our expectation that the revised terms in the formula will give a full range of structural thicknesses for various conditions of traffic loads and volumes. The new method of computing traffic indices will provide greater thicknesses for those highways carrying large volumes of heavy industrial traffic and lesser thicknesses on roads or streets having smaller amounts of traffic. For general use a detailed method of determining traffic constants has been presented in order that engineers may derive traffic constants that will fit their particular problem.

Having developed these theoretical considerations, and having revised two factors of the formula, we now feel that the thickness derived by the formula is in better relation to the loads applied and to the soils over which highways are built.

Acknowledgments

This paper covering changes in California's formula for designing flexible pavement structures represents the combined efforts of several people. The work was carried on in the Materials and Research Department under the direction of Francis N. Hveem, Materials and Research Engineer and Ernest Zube, Supervising Materials and Research Engineer. Special recognition should be given to Daniel R. Howe, Soils Engineering Associate, for his work on the cohesion phase of this study and to Joseph R. Santos, Assistant Physical Testing Engineer for his work on the development of the new traffic index formula.

Acknowledgment is also made of the contribution of William L. Warren, Supervising Highway Engineer of the Design Department, who worked closely with the Materials and Research Department during the development of the revised formula.

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(6) Highway Research Board Special Report 22
"The WASHO Road Test, Part 2"

TABLE I

Calculations to Determine
Yearly ADT Constants for Truck Groups
Based on 1955-56 Statewide Loadometer Survey

		2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
Axle Gp. Kips	Wh. Load Kips	Wh.Ld. Factor	No. in Gp.	EWL	Wh. Ld. Factor*	No. in Gp.	EWL	Wh. Ld. Factor*	No. in Gp.	EWL	Wh. Ld. Factor*	No. in Gp.	EWL	Wh. Ld. Factor*	No. in Gp.	EWL
2-8	2	.01	1734	17	.01	1738	17	.01	1263	13	.01	4761	48	.01	674	7
8-9	4-1/4	0.44	74	33	.48	383	184	.47	133	63	.49	1583	776	.51	206	105
9-10	4-3/4	0.77	65	50	.84	394	331	.82	102	84	.86	1076	925	.89	236	210
10-11	5-1/4	1.2	51	61	1.3	274	356	1.3	92	120	1.3	569	740	1.4	226	316
11-12	5-3/4	2.0	56	112	2.2	159	350	2.1	75	158	2.2	607	1335	2.3	145	334
12-13	6-1/4	3.0	34	102	3.3	155	512	3.2	98	314	3.3	731	2412	3.5	107	375
13-14	6-3/4	4.5	35	158	4.9	138	676	4.8	83	398	5.0	996	4980	5.2	154	801
14-15	7-1/4	6.4	29	186	6.9	132	911	6.8	122	830	7.1	1369	9720	7.4	113	836
15-16	7-3/4	9.0	20	180	9.8	119	1166	9.6	130	1248	10	1426	14260	10	84	840
16-17	8-1/4	12	18	216	13	76	988	13	103	1339	13	1242	16146	14	55	770
17-18	8-3/4	16	18	288	17	51	867	17	96	1632	18	899	16182	18	25	450
18-19	9-1/4	22	11	242	24	23	552	23	50	1150	24	375	9000	25	14	350
19-20	9-3/4	28	2	56	30	3	90	30	10	300	31	59	1829	32	3	96
20-22	10-1/2	41	3	123	45	3	135	44	6	264	46	17	782	47	4	188
22-24	11-1/2	64	2	128	69	-	-	68	1	68	71	4	284	74	-	-
24-26	12-1/2	98	-	-	106	-	-	104	-	-	109	1	109	113	-	-
Totals			2152	1952		3648	7135		2364	7981		15,715	79,528		2046	5678

*Based upon tandem effect (i.e., one tandem = one single 20% heavier than tandem wheel load)
50% tandem axles assumed

Table II

Table of Average Daily Truck Constants for Various Classes of Trucks

No. of Axles	Total Application	Total EWL	EWL per axle Application	EWL per Truck	*EWL for 365 Days	**EWL/year For One Truck One Direction
2	2,152	1,952	0.907	1.814	662	330
3	3,648	7,135	1.956	5.868	2,142	1,070
4	2,364	7,981	3.376	13.504	4,929	2,460
5	15,715	79,528	5.061	25.305	9,236	4,620
6	2,046	5,678	2.775	16.650	6,077	3,040

*Constants when traffic counts covers traffic in one direction only.

**Constants when traffic counts include trucks traveling in two directions.

EFFECT OF WHEEL LOAD AND REPETITION ON THICKNESS REQUIREMENT

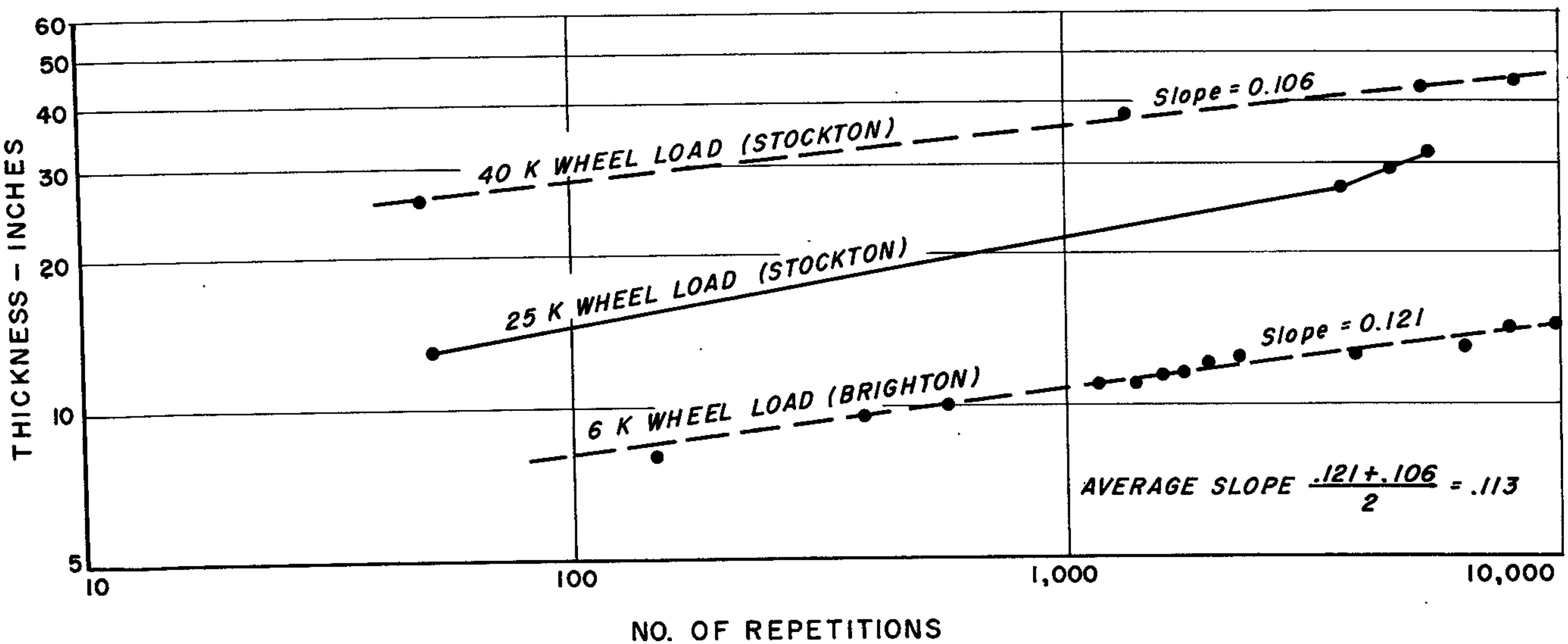
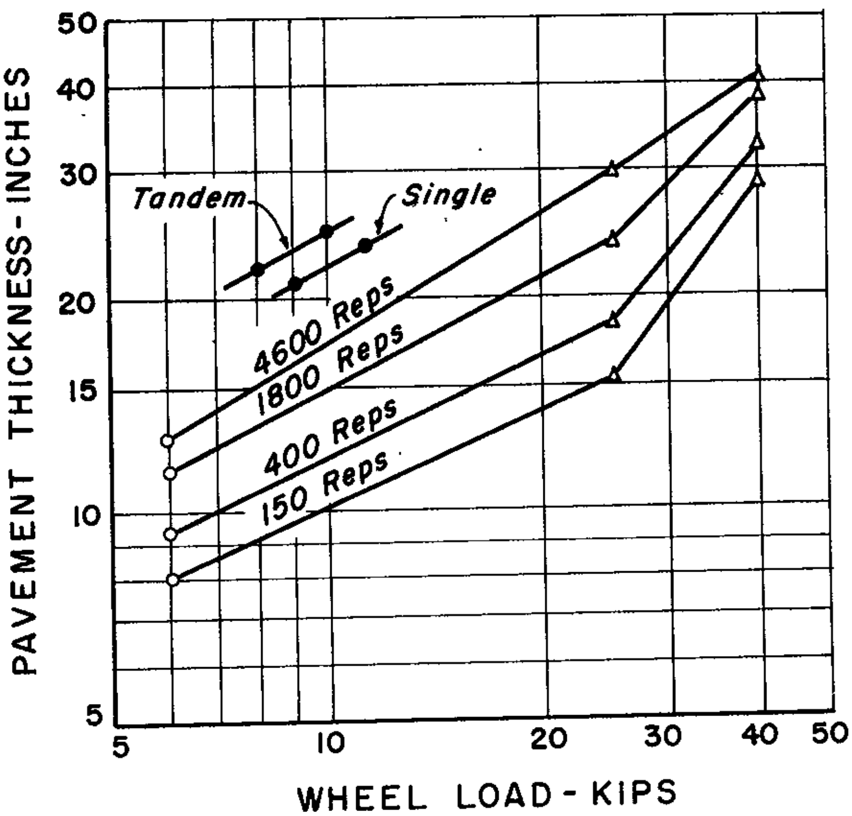


Fig. I

EFFECT OF WHEEL LOAD ON THICKNESS REQUIRED



- ● WASHO
- ○ Brighton
- Δ Stockton

WHEEL LOAD CONSTANTS

For Use With

EWL $_{57}$ Method

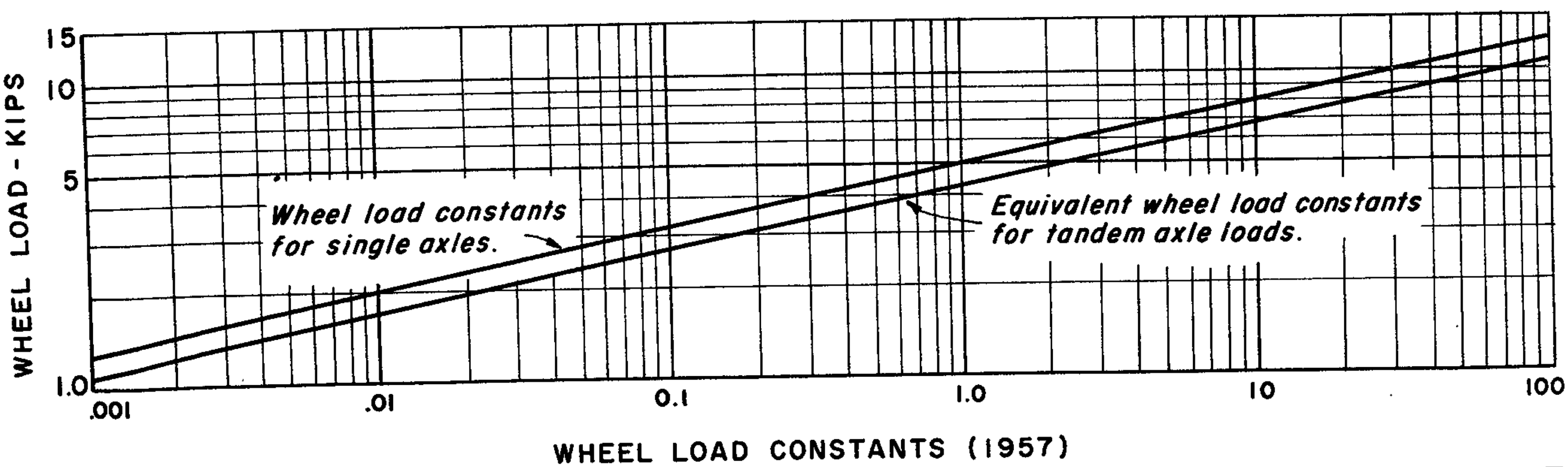
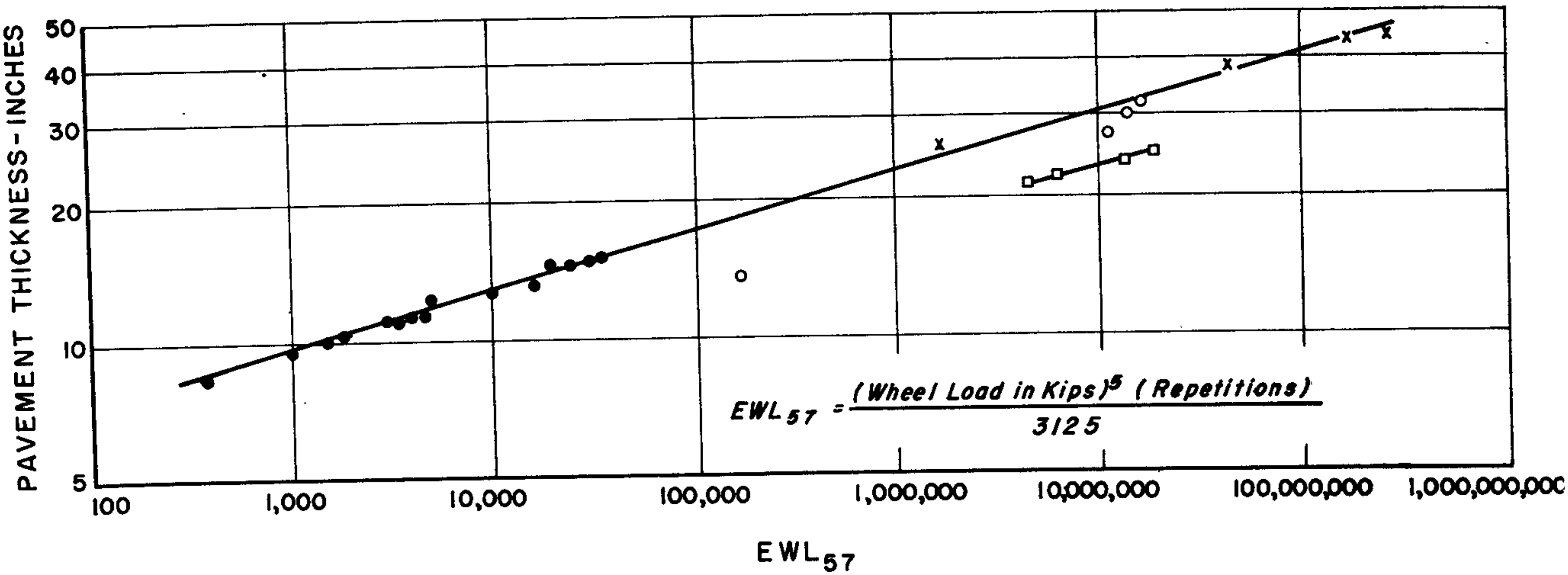


Fig. III

Fig. IV

CORRELATION OF EWL_{57} WITH PAVEMENT THICKNESS



$$EWL_{57} = \frac{(\text{Wheel Load in Kips})^5\ (\text{Repetitions})}{3125}$$

□ WASHO — 17 Avg. CBR Soil
● Brighton 6 KIP — 4 Avg. CBR Soil
○ Stockton 25 KIP, x Stockton 40 KIP — 5 Avg. CBR Soil

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS & RESEARCH DEPT.

DESIGN CHART FOR THICKNESS OF INCREMENTS OF PAVEMENT STRUCTURE

PROCEDURE FOR USE OF CHART

The chart solves the following formula:

$$T = \frac{0.095\,(T.I.)(90-R)}{\sqrt[5]{C}}$$

With a straightedge intersect Scale E at the R-value (R) of the soil tested and Scale F at the design Traffic Index (T.I.). Scale G is a turning point on the nomograph and indicates the thicknesses of gravel cover needed to sustain the design T.I., providing the cohesion of the surface layers is neglected. From the point on Scale G intersect Scale H at the cohesiometer value (C) of the layers above the material in question. The intersection with Scale I determines the required thickness (T) (corrected for the cohesion of the surface and/or base) of cover material needed to prevent plastic deformation of the soil tested.

EXAMPLE

Given:

R-value of a soil = 21
EWL = 19,200,000 (T.I. = 8.7)
Cohesiometer value (c) = 620*

*See VII-B-1, for method of calculation

Answer:

Thickness of cover (T) = 16"

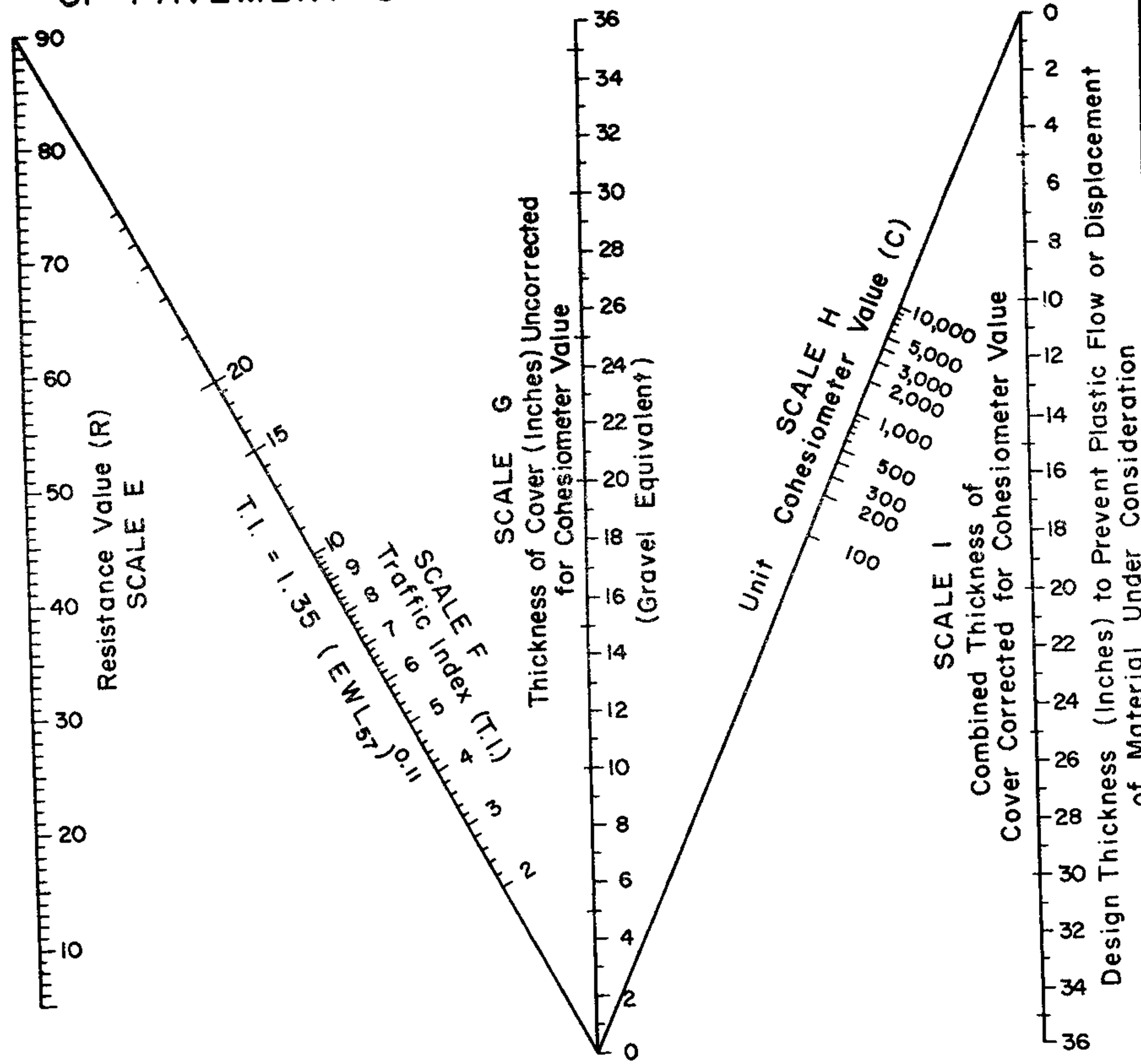


Fig. V